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Clay composition and swelling potential estimation of soils using depth of absorption bands in the SWIR (1100-2500 nm) spectral domain

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Swelling soils contain clay minerals that change volume with water content and cause extensive and expensive damage on infrastructures. Presence of clay minerals is traditionally a good estimator of soils swelling and shrinking behavior. Montmorillonite (i.e. smectite group), illite, kaolinite are the most common minerals in soils and are usually associated to high, moderate, and low swelling potential when they are present in significant amount. Characterization of swelling potential and identification of clay minerals of soils using conventional analysis are slow, expensive, and does not permit integrated measurements. SWIR (1100-2500 nm) spectral domain are characterized by significant spectral absorption bands related to clay content that can be used to recognize main clay minerals. Hyperspectral laboratory using an ASD Fieldspec Pro spectrometer provides thus a rapid and less expensive field surface sensing that permits to measure soil spectral properties. This study presents a new laboratory reflectance spectroscopy method that used depth of clay diagnostic absorption bands (1400 nm, 1900 nm, and 2200 nm) to compare natural soils to synthetic montmorillonite-illite-kaolinite mixtures. We observe in mixtures that illite, montmorillonite, and kaolinite content respectively strongly influence the depth of absorption bands at 1400 nm (D1400), 1900 nm (D1900), and 2200 nm (D2200). To attenuate or removed effects of abundance and grain size, depth of absorption bands ratios were thus used to performed (i) 3D (using D1900/D2200, D1400/D1900, and D2200/D1400 as axis), and (ii) 2D (using D1400/D1900 and D1900/D2200 as axis) diagrams of synthetic mixtures. In this case we supposed that the overall reduction or growth of depth absorption bands should be similarly affected by the abundance and grain size of materials in soil. In 3D and 2D diagrams, the mixtures define a triangular shape formed by two clay minerals as external envelop and the three clay minerals mixtures are located inside of the triangular shape. Clay composition of natural soils were estimated using 3D and 2D diagrams used as standard template from: (i) the average clay composition of the three closer mixtures when soil samples were plotted inside the triangular distribution of mixtures; and (ii) the closer mixture when the soil sample were plotted outside of the triangular distribution of mixtures. Comparison with X-ray diffraction analysis show reliable prediction of montmorillonite content that were used to estimate the swelling potential of soils. This method allows a simple, fast, and low cost method that classes soils into four swelling classes based on comparison with Methylene Blue test, and could be used as complementary or alternative method to traditional geotechnical analysis.